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Ahmed Al-Hmouz

*University of Wollongong*, [ahmeda@uow.edu.au](mailto:ahmeda@uow.edu.au)

Alison Freeman

*University of Wollongong*, [afreeman@uow.edu.au](mailto:afreeman@uow.edu.au)

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### Abstract

Delivery options for mobile learning are increasing, however new technologies alone will not improve the experience of mobile learners. There are a number of factors that impact on a typical learning experience, and many more when that learning experience becomes 'mobile'. This paper presents a framework to describe the factors that play an important role in delivering learning content to mobile learners, and their relationship to each other. Once the necessary information is collected about a user – either automatically (e.g. location, device, previous usage) or through user input (e.g. age) – learning content can be adapted to meet the unique and personal needs of that learner within their current context. The learning content framework allows consideration of individual learning styles and scenarios, device and application capabilities, and material structure, leading to a customization of the type and delivery format of learning information in response to the user. Ultimately, the personalized response to each user (whether they are working independently or in communication with other learners) improves user engagement and the overall learning experience, as well as saving time.

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# Learning on Location: An Adaptive Mobile Learning Content Framework

Ahmed Al-Hmouz and Alison Freeman  
School of Information Systems and Technology  
Faculty of Informatics

University of Wollongong, Wollongong, Australia  
{aa998, afreeman}@uow.edu.au

## Abstract

*Delivery options for mobile learning are increasing, however new technologies alone will not improve the experience of mobile learners. There are a number of factors that impact on a typical learning experience, and many more when that learning experience becomes 'mobile'. This paper presents a framework to describe the factors that play an important role in delivering learning content to mobile learners, and their relationship to each other. Once the necessary information is collected about a user – either automatically (e.g. location, device, previous usage) or through user input (e.g. age) – learning content can be adapted to meet the unique and personal needs of that learner within their current context. The learning content framework allows consideration of individual learning styles and scenarios, device and application capabilities, and material structure, leading to a customization of the type and delivery format of learning information in response to the user. Ultimately, the personalized response to each user (whether they are working independently or in communication with other learners) improves user engagement and the overall learning experience, as well as saving time.*

## 1. Introduction

The advancement of technologies in wireless and handheld devices has created significant interest in mobile learning (m-learning) in recent years. New advanced phones are capable of exchanging voice, text, pictures and video. In addition, the wireless network provides high-speed connections with low costs to mobile users.

Fischer stated [1]: “the challenge in an information-rich world is not only to make information available to people at any time, at any place, and in any form, but specifically to say the right thing at the right time in the right way”. This paper considers not only the abilities of new technologies to deliver mobile learning, but the role of personalisation in mobile learning.

Mobile learning (m-learning) is “any sort of learning that happens when the learner is not at a fixed, predetermined location, or learning that happens when the learner takes advantage of learning opportunities offered by mobile technologies” [2]. Most current learning contents were designed for use with desktop computers and high-speed network connections. They usually contain rich media data such as image, audio, and video. Learning contents may not be suitable for presentation on devices with limited capability and limited network bandwidth. Moreover, the widespread problem in e-learning environments is that they cannot offer personalization for the student and that they can only present identical contents to all the learners. M-learning is already reaching a large number of learners and it offers a valuable advantage over traditional teaching with the possibility to adapt to individual learners, which is hard to achieve in the common teaching process.

Learning can occur in all situations and environments, however until recently the role of technology in this learning has been limited in many settings. With the advances in m-learning, it is becoming possible for learning activities facilitated by technology to occur everywhere: educational institutes, within homes, on buses and trains and in parks and restaurants. However, it must be noted that m-learning is still in its infancy and most current research projects are focusing on the connectivity problem of using wireless networks [3]. For example, unpredicted weather conditions may affect the learner's ability to accomplish a learning task [4].

## 2. Mobile Learning and Context Projects

Numerous projects attempting to implement m-learning in very specific contexts have been undertaken in recent years. These projects have had varied aims and levels of adaptation for individual users. There have also been many projects concerned primarily with context awareness and its impact on content delivery. A sample of such projects is discussed below.

- In the Electronic Guidebook [5], mobile web content was specifically created for the Exploratorium museum in San Francisco.
- Tampere University of Technology presented content in the form of a game. The electronic device was used to measure each student's knowledge level, and then adapted the speed of presenting new learning material [6].
- The Kidsroom project [7] at MIT Media laboratory provided a room that guides children through an interactive storytelling game. Materials were adapted according to the activity context.
- A mobile device is used along with a robot to educate visitors in a museum [8]. Spatial context and spatial interface are used to present different multimedia learning content at different demonstration places.
- Martin [9] designed a system for recommending activities for learners; this process is dependent on the learner's personal attributes, actions and the current context (location, time, available devices). The system can be used individually or collaboratively.
- Ogata and Yano [10] designed a context-aware language learning support system for learning Japanese polite expressions.
- The MOBIlearn project is an interactive model in which data is collected from sensors and translated to appropriate services. An adaptive learner interface system has also been developed within this project [11].
- Ketamo have implemented an m-learning environment (xTask) that adapts to different user devices (PC, PDA and WAP devices) [12].

Despite research into both m-learning and adaptation, few of the m-learning researchers have tackled the problems of adaptation of learning content based on learner models, learning styles and strategies [13]. These issues have been explored within the traditional web-based systems in numerous well-known projects. The main purpose of mobile learning applications is to deliver learning content based on each user's current situation. There are proposed frameworks and systems that achieve this goal [14] [15] [16] [17] [18] [19] [20] [21] [22] [23], all of which have an initial focus on technology and use the learner's context, style, preferences and knowledge.

Most of the projects referred to above have been concerned with the impact of context in relation to mobile learning. They did not address the mobile learner content and the importance of learning content in terms of adaptation techniques. These concerns are addressed in this research.

The need for adapting the learning content in an m-learning application that caters various learner contexts (physical and device) is very important. Learner context inputs can contain various demographic properties, as well as the learner's skills and capabilities, interests and preferences.

This paper presents an m-learning content framework that uses a new approach to m-learning content adaption. The main objective of this framework is to show that there are a number of factors that impact on a typical learning experience, and many more when that learning experience becomes 'mobile'. The framework describes the factors that play an important role in delivering learning content to mobile learners. It allows consideration of individual learning styles and scenarios, device and application capabilities, and material structure, leading to a customization of the type and delivery format of learning information in response to the user.

Section 3 of this paper provides an overview of key factors in the m-learning application success, and their relationship to each other, and an overview of machine learning based user profile framework is provided in Section 4. Section 5 presents the structure of the proposed m-learning content framework. Finally, in section 6 we conclude with some comments about future developments related to this work.

### 3. Key Factors in M-learning Application Success

Particularly in mobile learning applications, contextual and personal characteristics have a strong relationship with each other, i.e. personal characteristics determine a human behaviour and the behaviour determines the context. Figure 1 presents the key factors for a system to evaluate in order to provide personalization to mobile users. User adaptive systems aim to adapt learning content, location and presentation to each individual user's characteristics or behaviour in order to improve the interaction between users and the system. The process is based on storing and exploiting information about the user.

#### 3.1. Context

Dey, Abowd and Salber [24] define context as "any information that can be used to characterize the situation of an entity. An entity is a person, place, or object that is considered relevant for the interaction between a user and an application, including the user and the application themselves". Adaptive system developers can use context information in the following ways [23]: resolving references, tailoring lists of options, triggering automatic behaviours and tagging information for retrieval.

The awareness of learning context is important. A learning system should adapt the learning process in response to context change. The main goal for context-aware m-learning applications is to sense the mobile learner's situation (environment) and respond to it [25]. Shilit [26] divided context into three categories:

computing context, learner context, and physical context. Chen and Kotz [27] extended this list by adding a time context. Context has been divided into four categories [24]: identity, location, status, and time; and is said to have four dimensions in [28]: situation, network, device, and expertise. The framework presented in this paper considers all these.

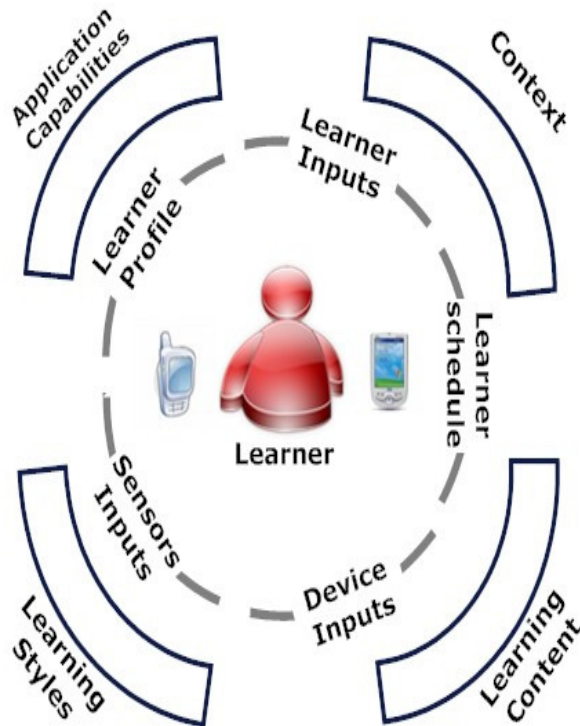


Figure 1. Key factors in m-learning application.

Learner context inputs can contain various demographic properties, as well as the learners' skills and capabilities, interest and preferences. Also, the current situation can be used as a factor for adapting the service. The context acquisition techniques used to gather the information required for adaptation rely on both explicit and implicit information collection. Explicit information relies on information provided by the user, usually through the use of forms with text boxes and check boxes. It often contains demographic information such as birth date, interests, marital status, job and personal characteristics. Implicit information is gathered by monitoring the user's interactions with a system and making assumptions as to their motivations and needs. Typical methods for gathering implicit information include determining user position using GPS, and sensing noise or time using a built-in microphone or clock. Extra parameters to the learner inputs, or a direct request to define a learner's current situation, may be required to successfully complete the adaptation process.

### 3.2. Learning Styles

It is believed that most people prefer some particular method of interacting with information. These methods of interaction are referred to as learning styles. Keefe [29] defined learning styles as characteristics which are "cognitive, affective and psychological behaviours that serve as relatively stable indicators of how learners perceive, interact with, and respond to the learning environment". A learning style is the method of learning particular to an individual that is presumed to allow that individual to learn best [30]. The adaptation process foundation is based on storing and exploiting information about the learners. However, learners differ in skills, aptitudes and preferences for processing information and applying this information to real world situations. In that regard, modeling the learner is a necessary and fundamental mechanism for providing effective personalization [31].

### 3.3. Application Capabilities

An m-learning application is a mobile software application that is used by the learner to accomplish learning activities, taking all contextual elements into consideration. The learning application capabilities for m-learning are concerned with: the different ways of interactions between learners, the amount of control over the adaptation process, different options that are given to the mobile learner in a specific learning activity, the amount of help and support provided to a learner when the learning activity begins, the privacy data (identification, learner profile) provided by the learning tool, and most importantly the interface capabilities of the learning tool. All of these capabilities will allow the content creators to tailor various alternatives of learning content according to meet the learner and application requirements.

### 3.4. Learning Content

A learning content repository is any written digital material sources. Separating the educational content into small segments allows ease of use of the content. Digital resources are usually described with additional metadata attached to them and later arranged into more meaningful content such as lectures, courses, programs, tests, videos, images and quizzes. Metadata repositories help in categorizing and searching for learning objects. The m-learning application must be able to support all relevant file formats and content types so that learners can access all required content seamlessly. The ability of the application to deliver all content allows the learner to interact in the most natural way possible with the



application, thereby allowing their true preferences and learning style to be identified by the system. This, in turn, helps the system adapt more accurately and efficiently to each learner's preferred style.

The learning content format/type varies for different learning scenarios, contexts and interfaces, and each format provides distinct support options for learners. The learning content delivered to the learner may be delivered in any format/type, such as text, animation, audio, video, picture or slideshow. The determination of format/type of the learning content is decided by sets of constraints and requirements such as display screen size, processing power, memory and location.

#### 4. Machine Learning Based User Profile Framework

A new framework that depicts the process of adapting learning content to satisfy individual learner characteristics by taking into consideration a user's learning style has been previously published [14]. It is fundamentally grounded on a number of logical layers: Context Acquisition, Information Classification, Learner Model, Information Extraction, Learner Profile Representation, Reasoning and Interface as shown in figure.2. It is a generic framework for selecting the appropriate learning style for learners based on their learner preferences and contextual features.

Within the model, the authors first consider the application that supplies the events that have occurred in a specific location. In the case of mobile learning adaptation, seven adaptation layers need to be considered.

- Context Acquisition Layer: The context acquisition layer is used to gather the information required for adaptation.
- Information Classification Layer: This layer deals with all data obtained from the previous stage by categorizing the data into several class types (Personal context and Shared context).
- Learner Model Layer: A learner model is defined as a set of information structures designed to represent one or more of the following elements [32]: Goals, plans; The classification of a learner stereotypes; Learner behaviour; The assumptions about the learner based on the interaction history; and/or The interaction histories of many learners into groups.
- Information Extraction Layer: The process of adaptation is based on storing and exploiting information about the user. This layer assesses, analyses, verifies and filters the data based on the current user situation.
- Learner Profile Representation: specifying user interests plays an important role in order to achieve personalized services. This can be done using a

machine learning algorithm, which takes a learner's information for input, then compares and analyses the learner's need, interest and environment.

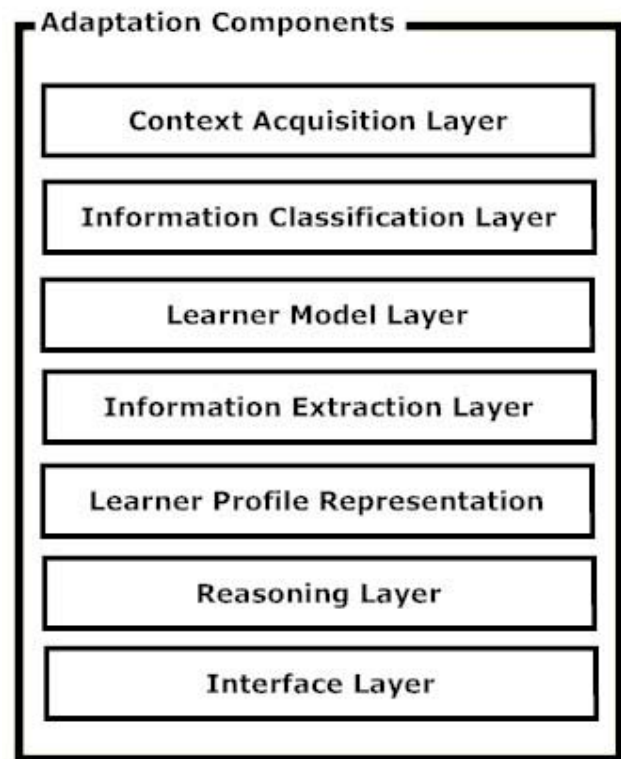


Figure 2. Adaptation components [14].

- Reasoning Layer: The output of this layer is a set of structural descriptions of what has been learned about user behaviour and user interests.
- Interface Layer: The interface layer is formed by the events that are processed by the adaptation system as well as the questions about the learner that it can answer.

In this paper, the authors proposed a solution to adapt learning content through the use of mobile technology, based on modeling the learner and all possible contexts related to his/her current situation.

#### 5. Learner Content Framework Structure

The concept of content adaptive learning is to develop the strategies and methods for creating learning contents that always meet learners' needs. Because the mobile devices and wireless network enable users to learn anytime anywhere, designing the adaptive learning contents based on learner profiles faces many contextual and learning contents challenges. The contextual challenges are those methodologies and techniques to build practical adaptive mobile learning environments for a specific learning task. The learning contents challenges

are those techniques to model the contents to be more feasible for mobile learning application.

To effectively address the adaptation problem we must consider the problem from both sides – the learning context and the learning content – by the integration of two frameworks. The first framework deals with the learner context and has been described in section 4; the second framework is discussed below.

In this section, we present our proposed framework for modeling learning content of mobile learning application. The proposed framework is a system with three steps, once the necessary information is collected about a user either automatically (e.g. location, device, previous usage) or through user input (e.g. age), learning content can be adapted to meet the unique and personal needs of that learner within their current context. The learning content model allows consideration of individual learning styles, learner context, application capabilities, and material structure, leading to a customization of the type and delivery format of learning information in response to the user. The learning content modeling is a very important step and cannot be considered as minor task in the entire modeling process.

The generic process of learning content modeling is depicted in Figure. 3. First, an instructor uses authoring tools to design learning content from scratch. The basic form of learning content is a set of raw learning content such as lecture notes, syllabus, a subject outline, and self-reading tutorials. These elements of raw learning content can be part of one or more course structures, each of which are viewed as instructional designs within the m-learning application. To enable the creator to combine or reuse the learning content to suit the varied needs of learners, and to ensure that learners access information in a useful format, the learning materials must be modified into a more appropriate form.

Once the content is organised into an appropriate format, the instructor must consider whether the learning content fits into the course structure that is being adopted by the instructor for the learner or group of learners. The course structure provides details about the learning content, such as the activities the learner has to complete, the classes the learner is required to attend, assignment details, and examinations. All these course activities have their own formats, which the instructor has to design and fit into mobile device technology.

The design process will consider the different forms of learning content that have been created by the instructor. M-learning content must be designed with the overall learning scenario in mind. In many learning scenarios it is necessary for tasks to be completed in a specified sequence; this structure can be built into the system by the instructor. Each learning activity that is conducted on the learner's mobile device and results in task completion can be considered as one element in a larger learning scenario.

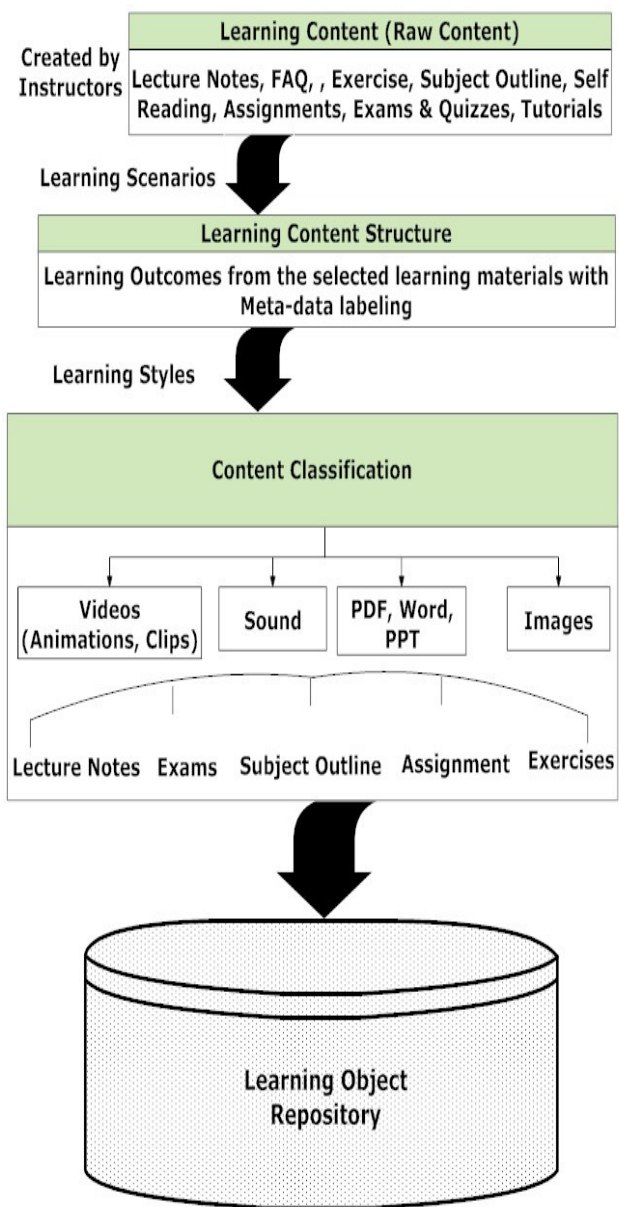


Figure 3. Modeling process for m-learning content

Learning content modeling process involves categorising the learners based on learning styles. Each category has its own learning content representation that facilitates effective learning that matches the style of that learner. For example, learning styles identified by Dunn and Dunn [30] place learners into categories such as environmental, emotional, physical, sociology and personality. Using the model in figure. 3, the application of learner styles and preferences such as auditory (audio lectures), visual (diagrams, graphs), linguistic (Word, PowerPoint), and a combination of these, could be used. Instructors can consciously choose to provide content in varied learning styles, and learners (or the adaptive system on behalf of the learner) can select content that meets personalised preferences.



Learning through a mobile device makes learning truly personalized. The learners have the option to choose learning content based on their interest, thus making learning very learner-centric. In contrast to typical electronic learning products, this access to personalized information means each learner gets the resources they need in a timely manner while minimizing wasted bandwidth. The flexibility to access specific information using mobile devices also helps to increase the productivity of an individual. Providing immediate access to relevant and interesting information, based on the individual user's requirements, encourages use and increases engagement because learners are able to access the information they want wherever they are.

## 6. Conclusion and Future Work

This paper has presented a new framework that depicts the process of modeling learning content to satisfy individual learner characteristics by taking into consideration his/her context, learning style, application capabilities, learning content. The proposed design includes three steps which can be regarded as subsystems of the adaptation framework that described in section 4. Learning content (raw) is to be designed by the instructor using authoring tools to design learning content from scratch. The learning content structure provides details about the learning content, such as the activities the learner has to complete. Learning content classification involves categorising the learners based on learning styles. Each category has its own learning content representation that facilitates effective learning that matches the style of that learner. The implementation of the system is currently in progress and the effectiveness of the system will be evaluated both quantitatively and qualitatively. The ultimate goal of the framework is to provide a logical structure for the process of adapting learning content to modeling process for learning content to be used for mobile users.

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